# ATENT COOPERATION TR TY

From the INTERNATIONAL BUREAU

## PCT

### NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

| | |
|---|---|
| **Date of mailing** (day/month/year)<br>04 April 2001 (04.04.01) | |
| **International application No.**<br>PCT/AU00/00898 | **Applicant's or agent's file reference**<br>8063WO |
| **International filing date** (day/month/year)<br>28 July 2000 (28.07.00) | **Priority date** (day/month/year)<br>10 August 1999 (10.08.99) |
| **Applicant**<br>TAYLOR, Scott, Phillip, Neale | |

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

06 March 2001 (06.03.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

| | |
|---|---|
| The International Bureau of WIPO<br>34, chemin des Colombettes<br>1211 Geneva 20, Switz rland | Authorized officer<br>Charlotte ENGER |
| Facsimile No.: (41-22) 740.14.35 | Telephone No.: (41-22) 338.83.38 |

L 698184700

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU00/00898

**A. CLASSIFICATION OF SUBJECT MATTER**

Int. Cl. [7]: B61B 13/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC: B61B, E01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC AS ABOVE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT: B61B AND E01B using keywords, eg WHEEL:, BOGIE#, GUID:, STEER:, DIRECT, etc, etc.

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | WO 94/18048 A (BISHOP) 18 August 1994 | |
| A | WO 95/20704 A (ICONS OY) 3 August 1995 | |
| A | US 4000702 A (MACKINTOSH) 4 January 1977 | |

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 7 August 2000 | |
| Name and mailing address of the ISA/AU<br>AUSTRALIAN PATENT OFFICE<br>PO BOX 200, WODEN ACT 2606, AUSTRALIA<br>E-mail address: pct@ipaustralia.gov.au<br>Facsimile No. (02) 6285 3929 | Authorized officer<br>I.A. KILBEY<br>Telephone No : (02) 6283 2115 |

**INTERNATIONAL SEARCH REPORT**
Information on patent family members

International application No.
**PCT/AU00/00898**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

| Patent Document Cited in Search Report | | Patent Family Member | | | | | |
|---|---|---|---|---|---|---|---|
| WO | 94/18048 | AU | 59958/94 | CA | 2154686 | CN | 1120329 |
| | | EP | 681541 | PL | 310107 | US | 5730064 |
| WO | 95/20704 | AU | 15387/95 | FI | 940439 | | |

END OF ANNEX

L 698184378

PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

| Applicant's or agent's file reference 8063wo | FOR FURTHER ACTION | See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416). |
|---|---|---|
| International Application No. PCT/AU00/00898 | International Filing Date *(day/month/year)* 28 July 2000 | Priority Date *(day/month/year)* 10 August 1999 |

International Patent Classification (IPC) or national classification and IPC

Int. Cl. [7] B61B 13/00

Applicant

BISHOP AUSTRANS PTY LIMITED et al

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

[X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 3 sheet(s).

3. This report contains indications relating to the following items:

| | | |
|---|---|---|
| I | [X] | Basis of the report |
| II | [ ] | Priority |
| III | [ ] | Non-establishment of opinion with regard to novelty, inventive step and industrial applicability |
| IV | [ ] | Lack of unity of invention |
| V | [X] | Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement |
| VI | [ ] | Certain documents cited |
| VII | [ ] | Certain defects in the international application |
| VIII | [X] | Certain observations on the international application |

| Date of submission of the demand | Date of completion of the report |
|---|---|
| 6 March 2001 | 23 July 2001 |
| Name and mailing address of the IPEA/AU<br>AUSTRALIAN PATENT OFFICE<br>PO BOX 200, WODEN ACT 2606, AUSTRALIA<br>E-mail address: pct@ipaustralia.gov.au<br>Facsimile No. (02) 6285 3929 | Authorized Officer<br>**I.A. KILBEY**<br>Telephone No. (02) 6283 2115 |

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/AU00/00898

**I. Basis of the report**

1. With regard to the **elements** of the international application:*

☐ the international application as originally filed.

☒ the description, pages **1-3, 5-9** , as originally filed,
pages , filed with the demand,
page **4**, received on **11 April 2001** with the letter of **10 April 2001**

☒ the claims, page **10**,as originally filed,
pages , as amended (together with any statement) under Article 19,
pages , filed with the demand,
pages **11-12 (numbered 12-13)** ,received on **11 April 2001** with the letter of **10 April 2001**

☒ the drawings, pages **1/7-7/7** , as originally filed,
pages , filed with the demand,
pages , received on with the letter of

☐ the sequence listing part of the description:
pages , as originally filed
pages , filed with the demand
pages , received on with the letter of

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages

☐ the claims, Nos.

☐ the drawings, sheets/fig.

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report*

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

| | | |
|---|---|---|
| Novelty (N) | Claims 1-13 | YES |
| | Claims | NO |
| Inventive step (IS) | Claims 1-13 | YES |
| | Claims | NO |
| Industrial applicability (IA) | Claims 1-13 | YES |
| | Claims | NO |

2. Citations and explanations (Rule 70.7)

The invention is directed to a vehicle comprising at least one pair of wheels designed to run on faces of a guideway which incline downwardly towards the guideway centreline and that includes sensing means which sense lateral deviation from a reference path and send signals, via a control system, to actuation means to steer the wheels in response to the sensed lateral displacement.

No citation or obvious combination of citations discloses a vehicle having such a combination of features.

**VIII. Certain observations on the international application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

1. The description is not clear in that page 4 as amended repeats a passage appearing on page 3 (ie from the last two words of line 29 to the end of line 34 thereof). Similarly page 12 as amended is not clear in that it repeats the last two word of page 10. The claims are also not clear in that pages 12-13 as amended should be numbered as pages 11-12.
2. Claim 5 is not fully supported by the description in that the statement that the sensor is "laterally offset with the wheelset" implies that the wheelset is offset, contrary to the description

the guideway centreline at or near the intersection line are substantially resisted by perpendicular components of the engagement forces acting at the primary running faces, such that substantially all of the parallel components of the engagement forces acting at the primary running faces are available to steer the wheelset.

Preferably the intersection line passes through the centre of gravity of vehicle.

It is preferred that the sensing means comprises at least one sensor located either ahead or behind the wheelset, or laterally offset with the wheelset. Alternatively the sensing means comprises at least two sensors, one of which is located ahead of the wheelset and the other is located behind the wheelset.

It is preferred that the longitudinal disposed reference path is substantially contiguous with the guideway centreline.

Alternatively, it is preferred that the longitudinal disposed reference path is substantially parallel to, but laterally offset from the guideway centreline.

It is preferred that a secondary running face lies immediately adjacent to, and substantially parallel to, at least one primary running face.

It is preferred that the longitudinally disposed reference path is contiguous with the second running face.

Alternatively, it is preferred that a secondary running face lies immediately adjacent to and substantially parallel to each primary running face and the longitudinally disposed reference path is contiguous with the lateral centreline between the respective two secondary running faces.

second plane perpendicular to the axis of rotation of the other wheel passes through the centroid of its respective contact zone, the first and second planes intersecting along an intersection line disposed above and between the wheels, wherein horizontal forces acting on the wheelset substantially transverse to the guideway centreline at or near the intersection line are substantially resisted by perpendicular components of the engagement forces acting at the primary running faces, such that substantially all of the parallel components of the engagement forces acting at the primary running faces are available to steer the wheelset.

4. A vehicle as claimed in claim 3, wherein the intersection line passes through the centre of gravity of vehicle.

5. A vehicle as claimed in claims 1 to 3, wherein the sensing means comprises at least one sensor located either ahead or behind the wheelset, or laterally offset with the wheelset. Alternatively the sensing means comprises at least two sensors, one of which is located ahead of the wheelset and the other is located behind the wheelset.

6. A vehicle as claimed in claims 1 to 3, wherein the longitudinal disposed reference path is substantially contiguous with the guideway centreline.

7. A vehicle as claimed in claims 1 to 3, wherein the longitudinal disposed reference path is substantially parallel to, but laterally offset from the guideway centreline.

8. A vehicle as claimed in claims 1 to 3, wherein a secondary running face lies immediately adjacent to, and substantially parallel to, at least one of the primary running faces.

9. A vehicle as claimed in claim 8, wherein the longitudinally disposed reference path is contiguous with the second running face.

10. A vehicle as claimed in claims 1 to 3, wherein a secondary running face lies immediately adjacent to and substantially parallel to each primary running face and the longitudinally disposed reference path is contiguous with the lateral centreline between the respective two secondary running faces.

11. A vehicle as claimed in claims 8 to 10, wherein at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

12. A vehicle as claimed in claim 1, wherein the control system calculates a virtual longitudinally disposed reference path which is not necessarily parallel or contiguous with the guideway centreline.

PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

| | | |
|---|---|---|
| Applicant's or agent's file reference<br>8063wo | **FOR FURTHER ACTION** | See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416). |
| International Application No.<br>**PCT/AU00/00898** | International Filing Date *(day/month/year)*<br>28 July 2000 | Priority Date *(day/month/year)*<br>10 August 1999 |
| International Patent Classification (IPC) or national classification and IPC<br>**Int. Cl.** [7] B61B 13/00 | | |
| Applicant<br>BISHOP AUSTRANS PTY LIMITED et al | | |

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

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   [X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

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| I | [X] | Basis of the report |
| II | [ ] | Priority |
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| V | [X] | Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement |
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| VII | [ ] | Certain defects in the international application |
| VIII | [X] | Certain observations on the international application |

| | |
|---|---|
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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/AU00/00898

**I. Basis of the report**

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☒ the claims, page **10**,as originally filed,
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pages , filed with the demand,
pages **11-12** (numbered **12-13**) ,received on **11 April 2001** with the letter of **10 April 2001**

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☐ filed together with the international application in computer readable form.

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4. ☐ The amendments have resulted in the cancellation of:

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☐ the claims, Nos.

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** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report*

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

| | | |
|---|---|---|
| Novelty (N) | Claims **1-13** | **YES** |
| | Claims | **NO** |
| Inventive step (IS) | Claims **1-13** | **YES** |
| | Claims | **NO** |
| Industrial applicability (IA) | Claims **1-13** | **YES** |
| | Claims | **NO** |

2. Citations and explanations (Rule 70.7)

The invention is directed to a vehicle comprising at least one pair of wheels designed to run on faces of a guideway which incline downwardly towards the guideway centreline and that includes sensing means which sense lateral deviation from a reference path and send signals, via a control system, to actuation means to steer the wheels in response to the sensed lateral displacement.

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1. The description is not clear in that page 4 as amended repeats a passage appearing on page 3 (ie from the last two words of line 29 to the end of line 34 thereof). Similarly page 12 as amended is not clear in that it repeats the last two word of page 10. The claims are also not clear in that pages 12-13 as amended should be numbered as pages 11-12.
2. Claim 5 is not fully supported by the description in that the statement that the sensor is "laterally offset with the wheelset" implies that the wheelset is offset, contrary to the description

the guideway centreline at or near the intersection line are substantially resisted by perpendicular components of the engagement forces acting at the primary running faces, such that substantially all of the parallel components of the engagement forces acting at the primary running faces are available to steer the wheelset.

Preferably the intersection line passes through the centre of gravity of vehicle.

It is preferred that the sensing means comprises at least one sensor located either ahead or behind the wheelset, or laterally offset with the wheelset. Alternatively the sensing means comprises at least two sensors, one of which is located ahead of the wheelset and the other is located behind the wheelset.

It is preferred that the longitudinally disposed reference path is substantially contiguous with the guideway centreline.

Alternatively, it is preferred that the longitudinally disposed reference path is substantially parallel to, but laterally offset from the guideway centreline.

It is preferred that a secondary running face lies immediately adjacent to, and substantially parallel to, at least one primary running face.

It is preferred that the longitudinally disposed reference path is contiguous with the second running face.

Alternatively, it is preferred that a secondary running face lies immediately adjacent to and substantially parallel to each primary running face and the longitudinally disposed reference path is contiguous with the lateral centreline between the respective two secondary running faces.

second plane perpendicular to the axis of rotation of the other wheel passes through the centroid of its respective contact zone, the first and second planes intersecting along an intersection line disposed above and between the wheels, wherein horizontal forces acting on the wheelset substantially transverse to the guideway centreline at or near the intersection line are substantially resisted by perpendicular components of the engagement forces acting at the primary running faces, such that substantially all of the parallel components of the engagement forces acting at the primary running faces are available to steer the wheelset.

4. A vehicle as claimed in claim 3, wherein the intersection line passes through the centre of gravity of vehicle.

5. A vehicle as claimed in claims 1 to 3, wherein the sensing means comprises at least one sensor located either ahead or behind the wheelset, or laterally offset with the wheelset.

6. A vehicle as claimed in claims 1 to 3, wherein the sensing means comprises at least two sensors, one of which is located ahead of the wheelset and the other is located behind the wheelset.

7. A vehicle as claimed in claims 1 to 3, wherein the longitudinally disposed reference path is substantially contiguous with the guideway centreline.

8. A vehicle as claimed in claims 1 to 3, wherein the longitudinally disposed reference path is substantially parallel to, but laterally offset from the guideway centreline.

9. A vehicle as claimed in claims 1 to 3, wherein a secondary running face lies immediately adjacent to, and substantially parallel to, at least one of the primary running faces.

10. A vehicle as claimed in claim 9, wherein the longitudinally disposed reference path is contiguous with the second running face.

11. A vehicle as claimed in claims 1 to 3, wherein a secondary running face lies immediately adjacent to and substantially parallel to each primary running face and the longitudinally disposed reference path is contiguous with the lateral centreline between the respective two secondary running faces.

12. A vehicle as claimed in claims 9 to 11, wherein at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

13. A vehicle as claimed in claim 1, wherein the control system calculates a virtual longitudinally disposed reference path which is not necessarily parallel or contiguous with the guideway centreline.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 February 2001 (15.02.2001)

PCT

(10) International Publication Number
WO 01/10697 A1

(51) International Patent Classification[7]: B61B 13/00

(21) International Application Number: PCT/AU00/00898

(22) International Filing Date: 28 July 2000 (28.07.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PQ 2103 10 August 1999 (10.08.1999) AU
PQ 4352 1 December 1999 (01.12.1999) AU

(71) Applicant *(for all designated States except US)*: **BISHOP AUSTRANS LIMITED** [AU/AU]; 10 Waterloo Road, North Ryde, NSW 2113 (AU).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **TAYLOR, Scott, Phillip, Neale** [AU/AU]; 45 Avonlea Drive, Carlingford, NSW 2118 (AU).

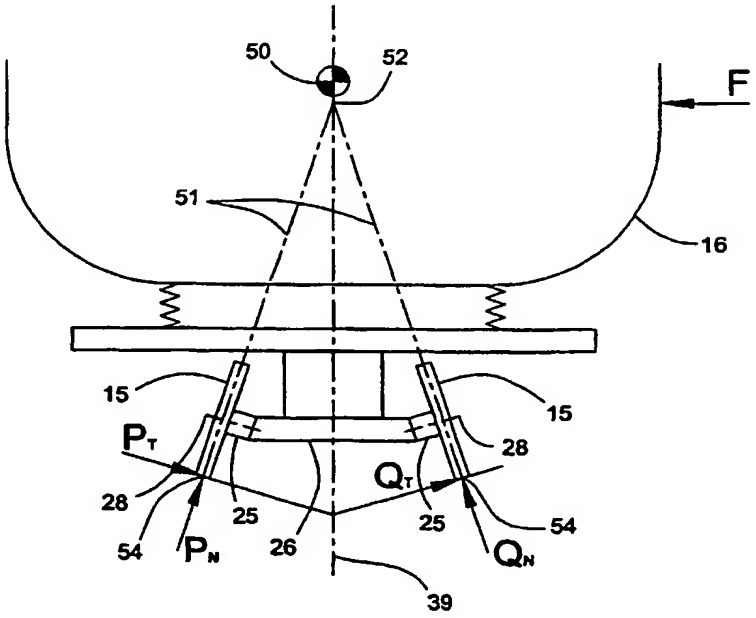
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

**Published:**
— *With international search report.*

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: A VEHICLE WITH A STEERABLE WHEELSET




(57) Abstract: A vehicle where respective inwardly inclined wheels (15) of a steerable wheelset run on respective inwardly sloping faces (54) of a guideway having centreline (39). The vehicle having sensing means for sensing lateral displacement of the wheelset relative to a longitudinal reference path. The sensing means signalling a control system including actuating means to steer the wheelset in response to sensed lateral displacement thereof.

WO 01/10697 A1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU00/00898

**A. CLASSIFICATION OF SUBJECT MATTER**

Int. Cl. [7]: B61B 13/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC: B61B, E01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC AS ABOVE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT: B61B AND E01B using keywords, eg WHEEL:, BOGIE#, GUID:, STEER:, DIRECT, etc, etc.

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | WO 94/18048 A (BISHOP) 18 August 1994 | |
| A | WO 95/20704 A (ICONS OY) 3 August 1995 | |
| A | US 4000702 A (MACKINTOSH) 4 January 1977 | |

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 7 August 2000 | |

| Name and mailing address of the ISA/AU | Authorized officer |
|---|---|
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**INTERNATIONAL SEARCH REPORT**
Information on patent family members

International application No.
**PCT/AU00/00898**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

| Patent Document Cited in Search Report | | Patent Family Member | | | | | |
|---|---|---|---|---|---|---|---|
| WO | 94/18048 | AU | 59958/94 | CA | 2154686 | CN | 1120329 |
| | | EP | 681541 | PL | 310107 | US | 5730064 |
| WO | 95/20704 | AU | 15387/95 | FI | 940439 | | |

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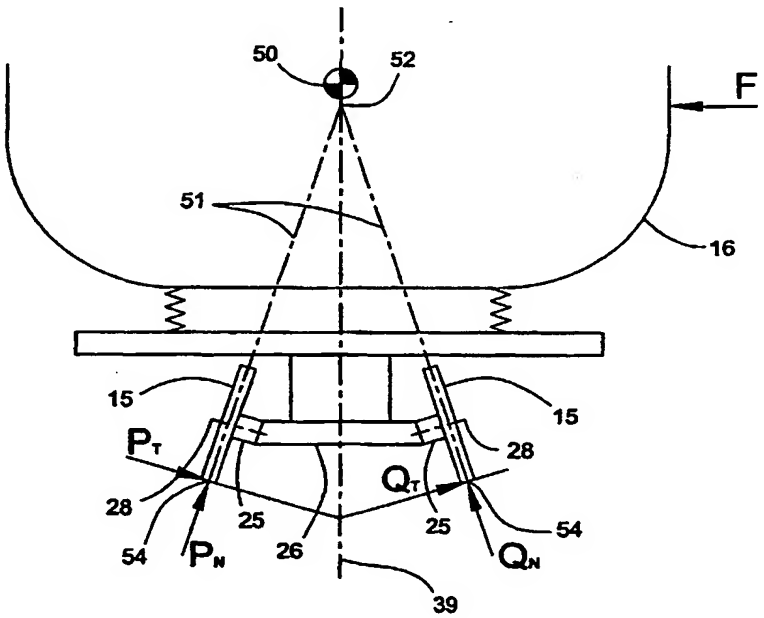
(54) Title: A VEHICLE WITH A STEERABLE WHEELSET




(57) Abstract: A vehicle where respective inwardly inclined wheels (15) of a steerable wheelset run on respective inwardly sloping faces (54) of a guideway having centreline (39). The vehicle having sensing means for sensing lateral displacement of the wheelset relative to a longitudinal reference path. The sensing means signalling a control system including actuating means to steer the wheelset in response to sensed lateral displacement thereof.

WO 01/10697 A1

# A VEHICLE WITH A STEERABLE WHEELSET

## TECHNICAL FIELD

This invention relates to a vehicle with a steerable wheelset. Whilst the invention is primarily described with an embodiment particularly suited for use with Automated Guideway Transit (AGT) systems of the type which use small, individual vehicles, capable of operating at high speeds, the present invention is also suitable for use with a variety of other rail or guideway systems.

## BACKGROUND

There are a number of known vehicles adapted to travel on rail or guideway systems which have steerable wheelsets.

One such system is disclosed in US Patent 4,982,671 (Chollet et al), and relates to a track guided vehicle. Such a vehicle is supported on bogies, where each bogie contains two wheelsets. Magnetic (or other) sensors are used to detect the lateral position of the bogie with respect to the track on which it is running. At least one sensor detects the angle between the two wheelsets. The two wheelsets are connected via linkages and actuators, such that the angle between the wheelsets can be altered to steer the bogie. A servo-control circuit receives signals from the sensors and controls the actuators to steer the wheelsets in response to the detected lateral position of the bogie.

Another known system is disclosed in European Patent 374,290 (Girod et al), and relates to a track guided vehicle. Such a vehicle comprises four wheels that can be independently steered. Laser sensors, located at the front and rear of the vehicle, are used to detect the difference between the track centreline and the vehicle longitudinal axis. A servo-control mechanism controls the steering actuators in order to steer the wheels in response to the sensed signals.

A disadvantage of both of these arrangem nts is that the lateral forces at the wheel-rail contact zone must serve a dual function, namely to steer the bogie and to oppose any lateral force, such as the centrifugal force experienced by a vehicle while cornering. Consequently the force available for steering the bogie is limited to the difference between the total available force and that already being used to oppose any external lateral forces. In a rail application where a steel wheel rolls on a steel rail, the total available force may be very low. This available force may be substantially required to react centrifugal force, with very little remaining force available to steer the wheelset leading to frequent contact between the wheel flanges and the rails.

A further known system is disclosed in US Patent 5,730,064 (Bishop), and relates to a self-steering bogie for track guided vehicle. The wheelsets are arranged such that a curvature in the rail generates a twist angle between the two wheelsets in the bogie when viewed in end elevation. The mechanism connecting the two wheelsets is arranged so as to steer the wheelsets, in response to rail curvature. A disadvantage of this arrangement when applied to small vehicle guideway systems, which typically use much sharper curves than normal rail systems, is the steer error resulting from twist angle supplied by rapidly changing superelevation. This may add to or subtract from the ideal steering angle required, causing the wheelset to deviate from its idealised path.

Preferably the present invention overcomes the above mentioned disadvantages by providing a vehicle with a steerable wheelset in which the effect of lateral or disturbing forces on the vehicle is minimised.

**SUMMARY OF INVENTION**

In one aspect the present invention is a vehicle with at least one steerable wheelset adapted to run on a guideway having two primary running faces laterally offset about

a guideway centreline, the wheelset comprising a pair of wheels, each wheel located on opposite sides of the wheelset adapted to

engage with a respective one of the two primary running faces, the vehicle further comprising sensing means for sensing lateral displacement of the wheelset with respect to a longitudinally disposed reference path, the sensing means producing a signal for a control system operably connected to an actuating means to steer the wheels in response to the sensed lateral displacement, **characterised in that** the axes of rotation of the wheels and the primary running faces are inclined downwardly towards the guideway centreline.

In a first embodiment each wheel exerts an engagement force with its respective primary running face, the engagement force on each wheel comprising a perpendicular component to its respective primary running face and a parallel component to its respective primary running face substantially transverse to the guideway centreline, wherein horizontal forces acting on the wheelset substantially perpendicular to the guideway centreline are substantially resisted by the sum of of the horizontal vectors of the perpendicular components.

In a second embodiment embodiment each wheel exerts an engagement force with its respective primary running face at a contact zone, the engagement force on each wheel comprising a first component perpendicular to its respective primary running face and a second component parallel to its respective primary running face substantially transverse to the guideway centreline, wherein a first plane perpendicular to the axis of rotation of one of the wheels passes through its respective contact zone, and a second plane perpendicular to the axis of rotation of the other wheel passes through its respective contact zone, the first and second planes intersecting along an intersection line disposed above and between the wheels, wherein horizontal forces acting on the wheelset substantially transverse to

the guideway centreline at or near the intersection line are substantially resisted by perpendicular components of the engagement forces acting at the primary running faces, such that substantially all of the parallel components of the engagement forces acting at the primary running faces are available to steer the wheelset.

Preferably the intersection line passes through the centre of gravity of vehicle.

It is preferred that the sensing means comprises at least one sensor located either ahead or behind the wheelset, or laterally offset with the wheelset. Alternatively the sensing means comprises at least two sensors, one of which is located ahead of the wheelset and the other is located behind the wheelset.

It is preferred that the longitudinal disposed reference path is substantially contiguous with the guideway centreline.

Alternatively, it is preferred that the longitudinal disposed reference path is substantially parallel to, but laterally offset from the guideway centreline.

It is preferred that a secondary running face lies immediately adjacent to, and substantially parallel to, at least one primary running face.

It is preferred that the longitudinally disposed reference path is contiguous with the second running face.

Alternatively, it is preferred that a secondary running face lies immediately adjacent to and substantially parallel to each primary running face and the longitudinally disposed reference path is contiguous with the lateral centreline between the respective two secondary running faces.

It is preferred that at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

It is preferred that the control system calculates a virtual longitudinally disposed reference path which is not necessarily parallel or contiguous with the guideway centreline.

## BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is an example of a vehicle according to the prior art, with two steerable wheelsets and incorporating steering sensors, actuators and a controller;

Figure 2 is a wheelset as found in the vehicle in Figure 1, showing the forces acting at the wheel-to-guideway running faces;

Figure 3 is a graph representing a typical relationship between side-force and slip angle for a wheel of the wheelset in Figure 2, and showing the force available for steering the wheels;

Figure 4 shows a schematic representation of a vehicle in accordance with a first embodiment of the present invention;

Figure 5 shows a schematic representation of a vehicle as shown in figure 4 when the vehicle is in a turn;

Figure 6 is a wheelset of the vehicle as shown in Figures 4-5, showing the forces acting at the wheel-to-guideway running faces;

Figure 7 is a graph similar to Figure 3, showing the force substantially available to steer the wheels in accordance with the first embodiment of the present invention;

Figure 8 is an illustration of the forces which act on the wheelset of the vehicle shown in Figure 6.

Figure 9 is a wheelset and rails as described in a second embodiment of the present invention;

Figure 10 shows a wheelset which is following a longitudinally disposed reference path other than the guideway centreline or secondary running face, according to a third embodiment of the present invention.

**MODE OF CARRYING OUT THE INVENTION**

Figures 1 and 2 show a vehicle running on a guideway (or track) of the type described in prior art. Such a vehicle incorporates two steerable wheelsets 1, attached to a vehicle body 2, and each wheelset 1 comprising axle 10 and two wheels 12. Steering actuators 3, are used to control the angle of the wheels with respect to the body. Sensors 4, detect the path error between the vehicle and guideway 5. A controller 6, processes the signals from the sensors and provides a control output to steering actuators 3. Upon detecting a path error, wheelsets 1 are steered in order to minimise the error.

In such a vehicle, axles 10 are substantially horizontal, as shown in Figure 2. When a lateral force F is applied to the vehicle body 2, it is reacted by the wheel-to-guideway engagement forces. These reaction forces can be resolved into perpendicular components, $A_N$ and $B_N$, and parallel components, $A_T$, $B_T$. When a wheel is steered at an angle to its heading, generating a slip angle, small levels of slip at its contact zone generate a lateral force ($A_T$, $B_T$). This lateral force is related

to this slip angle, with a typical relationship of the form shown in the graph of Figure 3. Such a relationship depends on both the wheel and guideway materials, along with their surface texture and lubrication. The available side force reaches a maximum at a slip angle $\delta_1$, beyond which no additional side force is available. In the example shown in Figure 2, wheelset 1 is steered so that lateral force F is reacted by a combination of $A_T$ and $B_T$ where $A_T$ is equal to $C_1$ as shown graphically in Figure 3. To generate a force $C_1$ wheelset 1 must be steered so that wheel 12 generates a slip angle $\delta_0$ to its heading. Only the remaining force $C_2$ is available to steer wheelset 1. If the required side force exceeds $C_2$, steering control is lost, the wheel slides in the direction of force F and is unable to follow a desired path. In such an event, the wheelset must rely on other means, such as wheel flanges, to ensure it remains safely on the guideway.

Figures 4 to 6 show a first embodiment of a vehicle according to the present invention comprising steerable wheelsets 21, each comprising axle 26 and two wheels 15 running on primary running faces 54 of guideway 19, attached to vehicle body 16. Steering actuators 17, are used to control the angle of wheelsets 21 with respect to vehicle body 16. Sensors 18, detect the lateral displacement between the vehicle and guideway 19. Controller 20 processes the signals from sensors 18, and provides an output to the steering actuators as a function of the lateral displacement of wheelset 21 with respect to guideway centreline 39. Upon detecting a lateral displacement error, wheelsets 21 are steered in order to minimise the error.

As shown in Figure 6, axes of rotation 28 of wheels 15 (mounted to stub axles 25) are inclined downwardly towards guideway centreline 39, as are primary running faces 54 at the wheel-to-guideway rolling interface. When a lateral force F is similarly applied to vehicle body 16, it is reacted by the wheel-to-guideway engagement forces. These can be resolved into first perpendicular components, $P_N$ and $Q_N$ and second parallel components, $P_T$ and $Q_T$. Each of these has a

component parallel to the applied lateral force F, and in combination react against this force.

On entering a turn, sensors 18 detect the deviation of the vehicle from guideway centreline 39, and controller 20 responds by steering wheelset 21 in the direction to reduce the deviation to zero. The resulting slip angle $\delta$ produces lateral forces at the wheel-to-guideway interface, causing the vehicle to accelerate toward the instantaneous centre of curvature. The centrifugal force F, acting on the centre of gravity 50 of the vehicle, is substantially reacted by an increase in the normal force, $P_N$, on the outer wheel, rather than an increase of the tangential forces, $P_T$ and $Q_T$. If $P_T$ and $Q_T$ are small, then the wheels do not need to be operating at a very large slip angle $\delta_o$ as shown in Figure 7. As a result, most of the maximum available tangential force, $C_2$, can be used to steer wheelset 21 and maintain its alignment with guideway centreline 39.

It is preferred that vehicle centre of gravity 50 and wheels 15 are arranged such that centre of gravity 50 is near the intersection line 52 of wheel planes 51. In this configuration, the centrifugal forces or external disturbance forces acting on centre of gravity 50, are substantially resisted by an increase in the normal force, $P_N$, on the outer wheel, and corresponding decrease in the normal force $Q_N$ on the inner wheel. As shown in Fig 8., the difference between the horizontal component $P_H$ of $P_N$ and the horizontal component $Q_H$ of $Q_N$, substantially resists the sum of the centrifugal or external disturbance force F.

Figure 9 depicts a second embodiment of the present invention, where the vehicle has a wheelset 21 comprising wheels 15 adapted to run on a guideway in the form of rails 19. Sensors 18 detect the proximity $d_1$, $d_2$ of the respective wheel 15 to the respective secondary running face 38 on rail 19. Sensed proximities $d_1$, $d_2$ are

averaged to generate the lateral position of the centreline 49 of the wheelset 21, with respect to the guideway centreline 39. In this embodiment each of the wheels 15 have a respective flange 37. Flange 37 engages with respective secondary running face 38 on rail 19 in the event of a steering failure, or excessive side load imparted on the vehicle via lateral acceleration or side wind loads. In other not shown embodiments, sensors 18 may detect the proximity of the wheels to some other feature on rail 19.

In a third embodiment of the invention as shown in Figure 10, sensors 18 may sense a different path to that of guideway running faces 40. In this embodiment a longitudinally disposed reference path 41, corresponding to the guideway centreline 39, is used. However, it should be understood that such a path may physically lie between guideway running faces 40, as depicted by phantom lines as reference path 41a and sensor 18a, or outside guideway running faces 40, as depicted by phantom lines as reference path 41b and sensor 18b. Alternatively the reference path may be a virtual path, bearing some predetermined varying relationship to the guideway running faces 40.

In other not shown embodiments other means of supporting and steering the wheels may be used. These include steering of individual wheels about individual steering axes, rather than steering complete wheelset 21. Sensors 18, are attached to wheelset 21, and sense its lateral displacement with respect to each primary running face 54 of guideway 19 and hence with respect to guideway centreline 39. Sensors 18 are preferably located ahead of wheelset 21 and are connected to controller 20. In other not shown embodiments, sensors 18 may be located ahead, beside, and/or even behind the wheels.

Sensors 18, controller 20 and actuators 17 may include hydraulic or electrical devices and combinations thereof.

It will be recognised by persons skilled in the art that numerous variations and modifications may be made to the invention without departing from the spirit and scope of the invention.

**CLAIMS:**

1. A vehicle with at least one steerable wheelset adapted to run on a guideway having two primary running faces laterally offset about a guideway centreline, the wheelset comprising a pair of wheels, each wheel located on opposite sides of the wheelset adapted to engage with a respective one of the two primary running faces, the vehicle further comprising sensing means for sensing lateral displacement of the wheelset with respect to a longitudinally disposed reference path, the sensing means producing a signal for a control system operably connected to an actuating means to steer the wheels in response to the sensed lateral displacement, **characterised in that** the axes of rotation of the wheels and the primary running faces are inclined downwardly towards the guideway centreline.

2. A vehicle as claimed in claim 1, wherein each wheel exerts an engagement force with its respective primary running face, the engagement force on each wheel comprising a perpendicular component to its respective primary running face and a parallel component to its respective primary running face substantially perpendicular to the guideway centreline, wherein horizontal forces acting on the wheelset substantially transverse to the guideway centreline are substantially resisted by the sum of the horizontal vectors of the perpendicular components.

3. A vehicle as claimed in claim 1, wherein each wheel exerts an engagement force with its respective primary running face at a contact zone, the engagement force on each wheel comprising a first component perpendicular to its respective primary running face and a second component parallel to its respective primary running face substantially transverse to the guideway centreline, wherein a first plane perpendicular to the axis of rotation of one of the wheels passes through the centroid of its r spective contact zone, and a

second plane perpendicular to the axis of rotation of the other wheel passes through the centroid of its respective contact zone, the first and second planes intersecting along an intersection line disposed above and between the wheels, wherein horizontal forces acting on the wheelset substantially transverse to the guideway centreline at or near the intersection line are substantially resisted by perpendicular components of the engagement forces acting at the primary running faces, such that substantially all of the parallel components of the engagement forces acting at the primary running faces ar available to steer the wheelset.

4. A vehicle as claimed in claim 3, wherein the intersection line passes through the centre of gravity of vehicle.

5. A vehicle as claimed in claims 1 to 3, wherein the sensing means comprises at least one sensor located either ahead or behind the wheelset, or laterally offset with the wheelset. Alternatively the sensing means comprises at least two sensors, one of which is located ahead of the wheelset and the other is located behind the wheelset.

6. A vehicle as claimed in claims 1 to 3, wherein the longitudinal disposed reference path is substantially contiguous with the guideway centreline.

7. A vehicle as claimed in claims 1 to 3, wherein the longitudinal disposed reference path is substantially parallel to, but laterally offset from the guideway centreline.

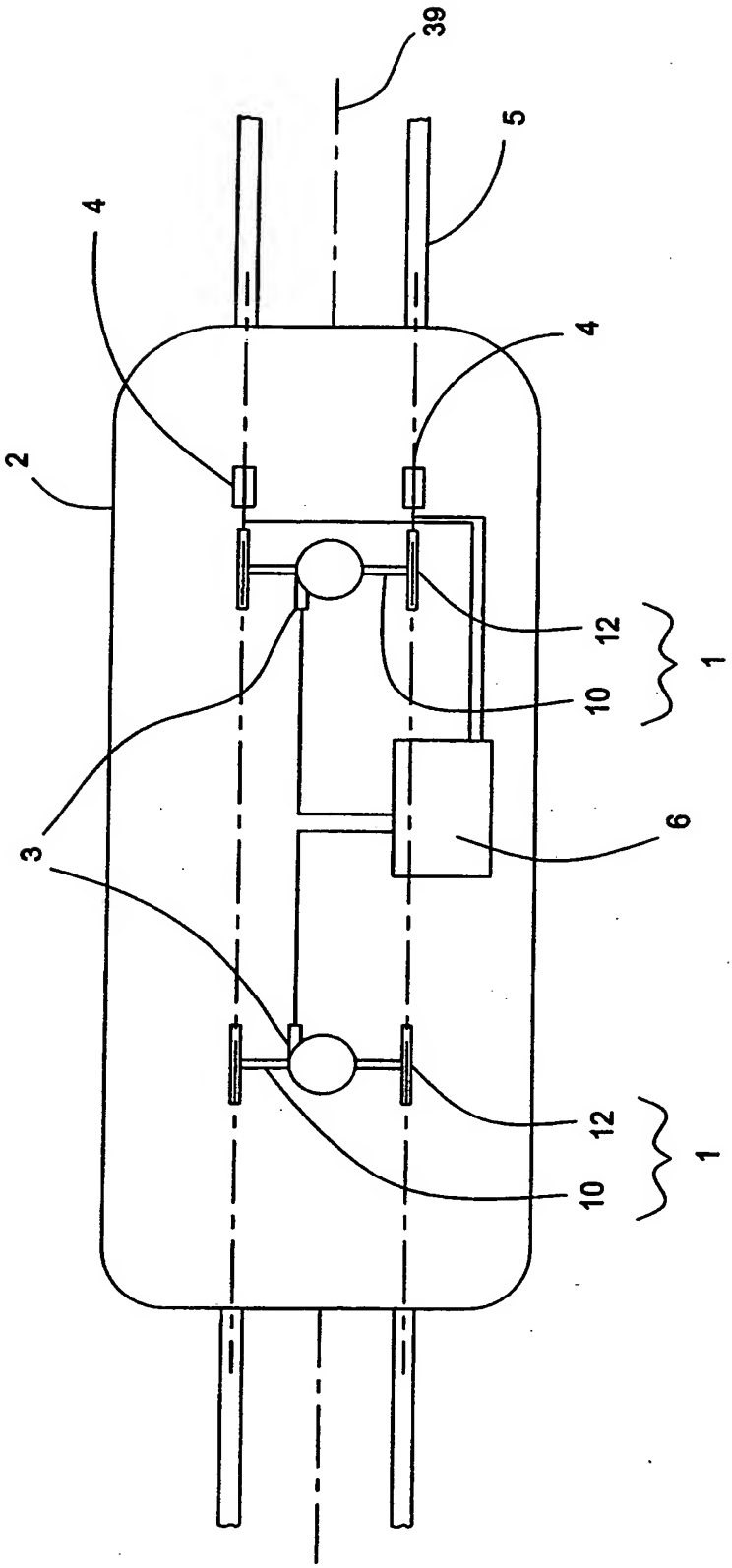
8. A vehicle as claimed in claims 1 to 3, wherein a secondary running face lies immediately adjacent to, and substantially parallel to, at least one of the primary running faces.

9. A vehicle as claimed in claim 8, wherein the longitudinally disposed reference path is contiguous with the second running face.

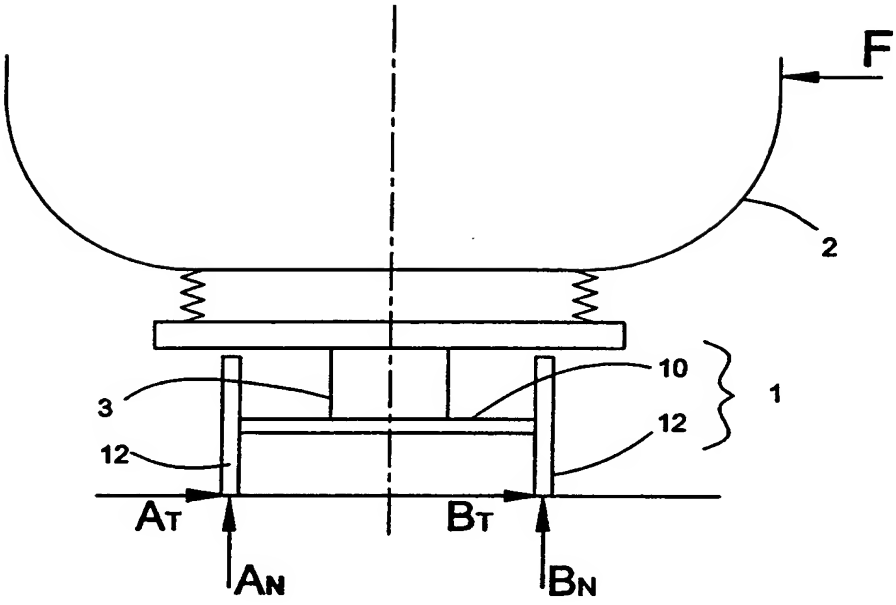
10. A vehicle as claimed in claims 1 to 3, wherein a secondary running face lies immediately adjacent to and substantially parallel to each primary running face and the longitudinally disposed reference path is contiguous with the lateral centreline between the respective two secondary running faces.

11. A vehicle as claimed in claims 8 to 10, wherein at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

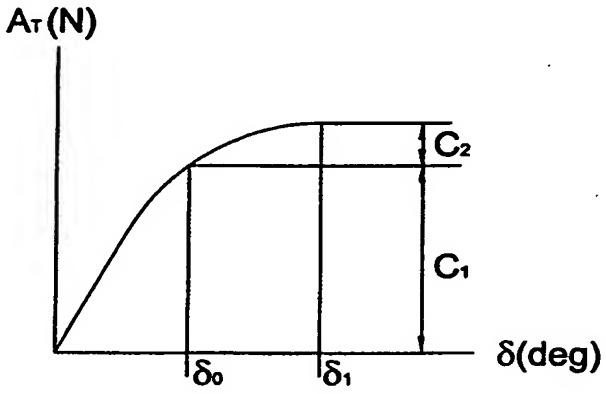
12. A vehicle as claimed in claim 1, wherein the control system calculates a virtual longitudinally disposed reference path which is not necessarily parallel or contiguous with the guideway centreline.




PRIOR ART
Figure 1




PRIOR ART
Figure 2




PRIOR ART
Figure 3

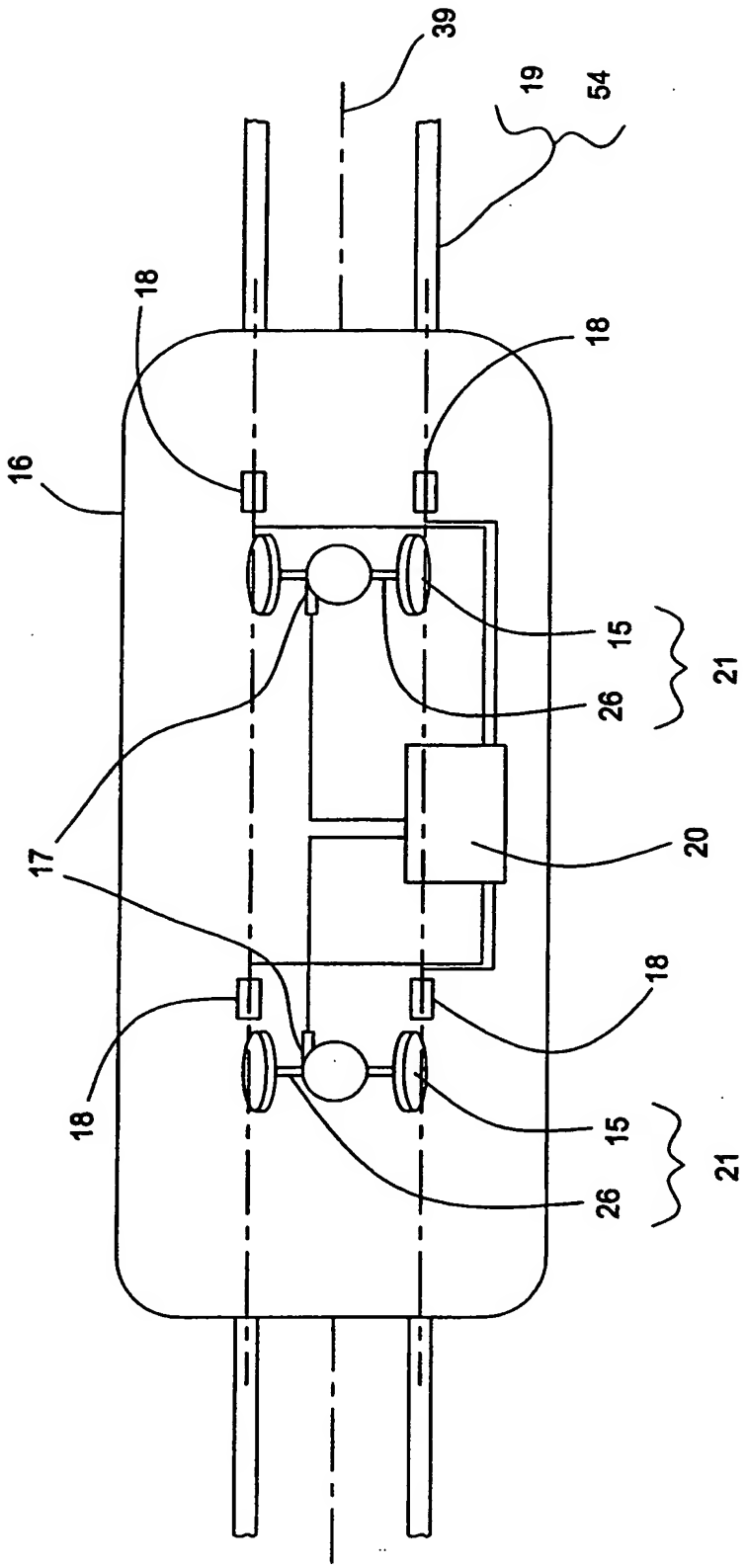



Figure 4

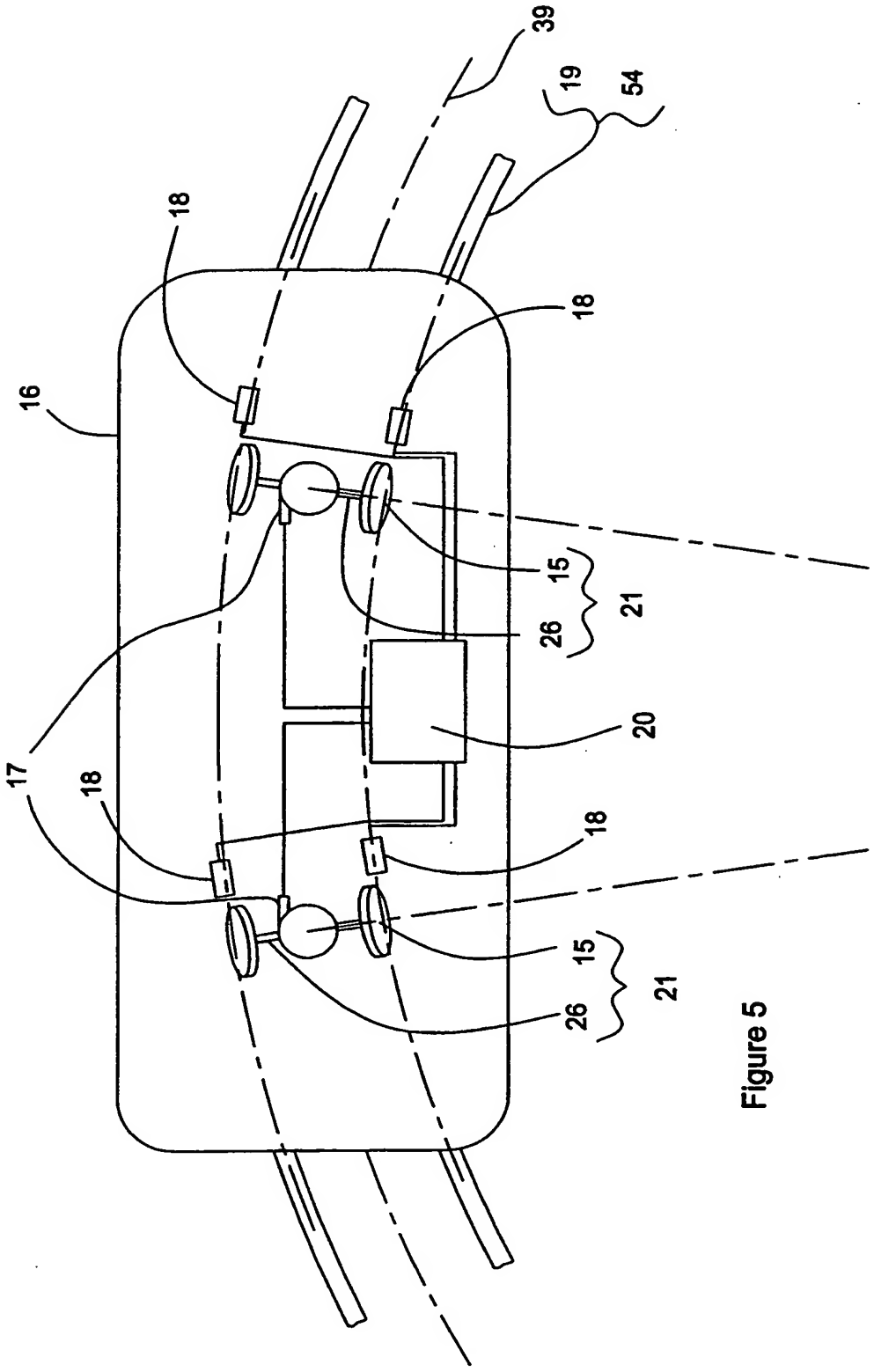



Figure 5

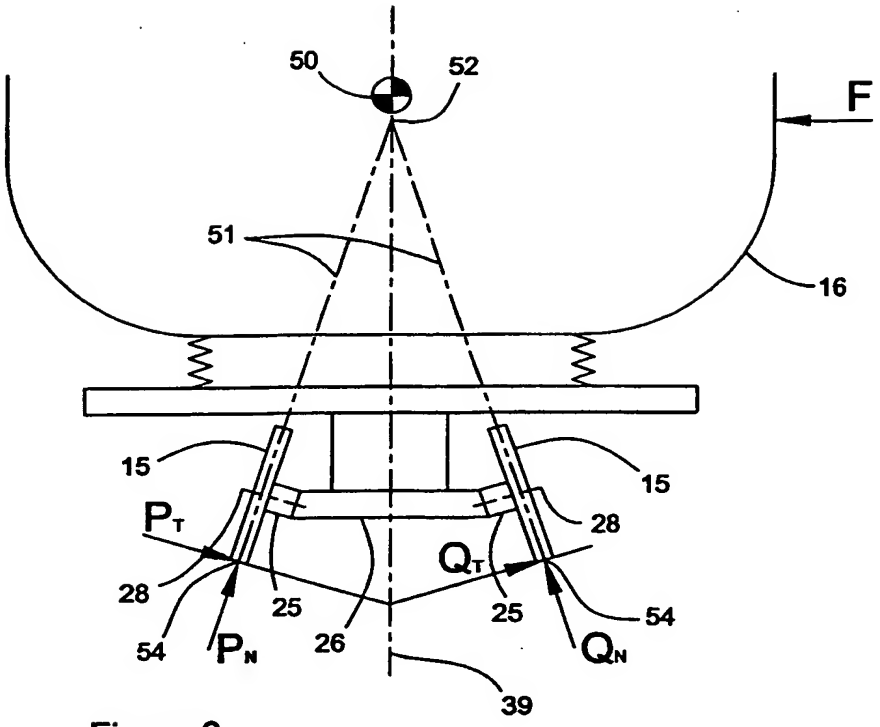



Figure 6

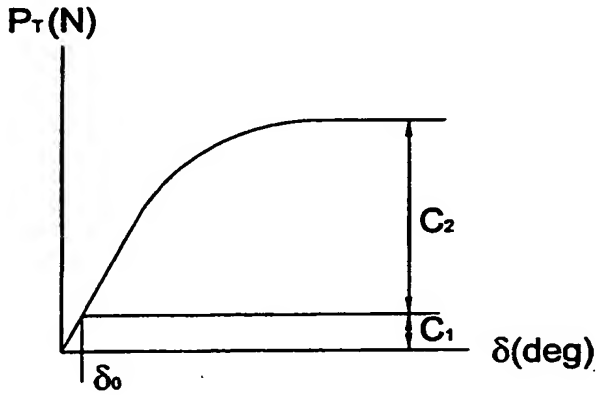



Figure 7

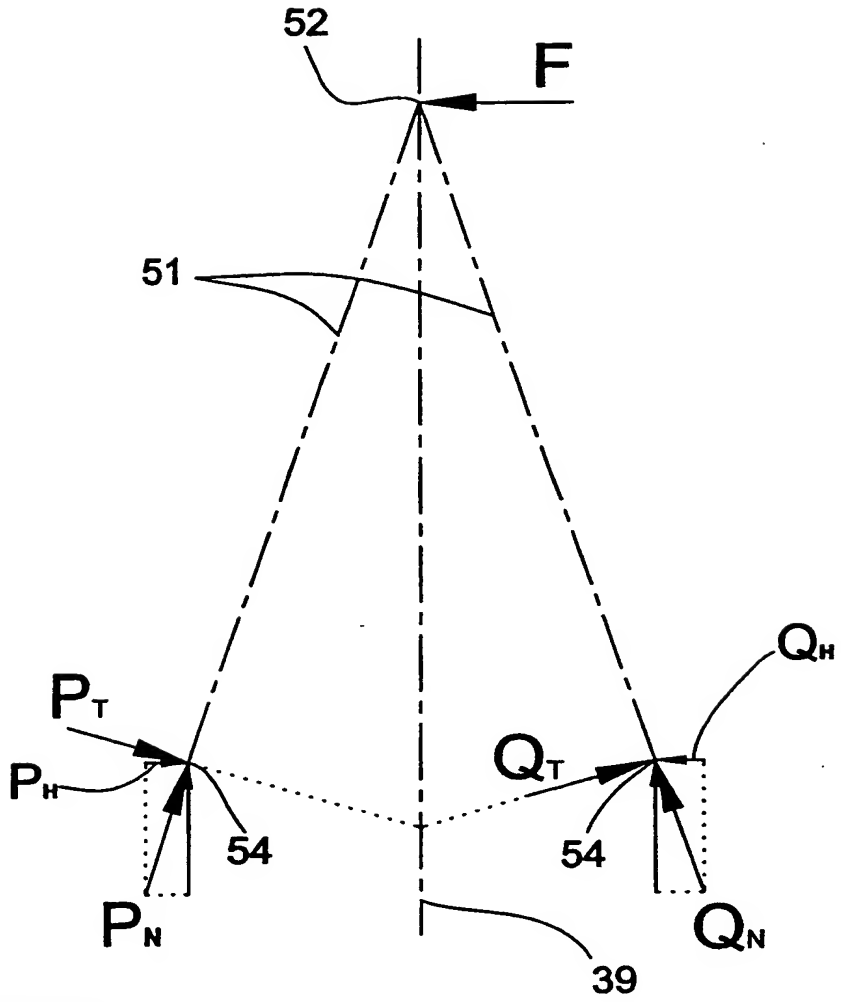



Figure 8

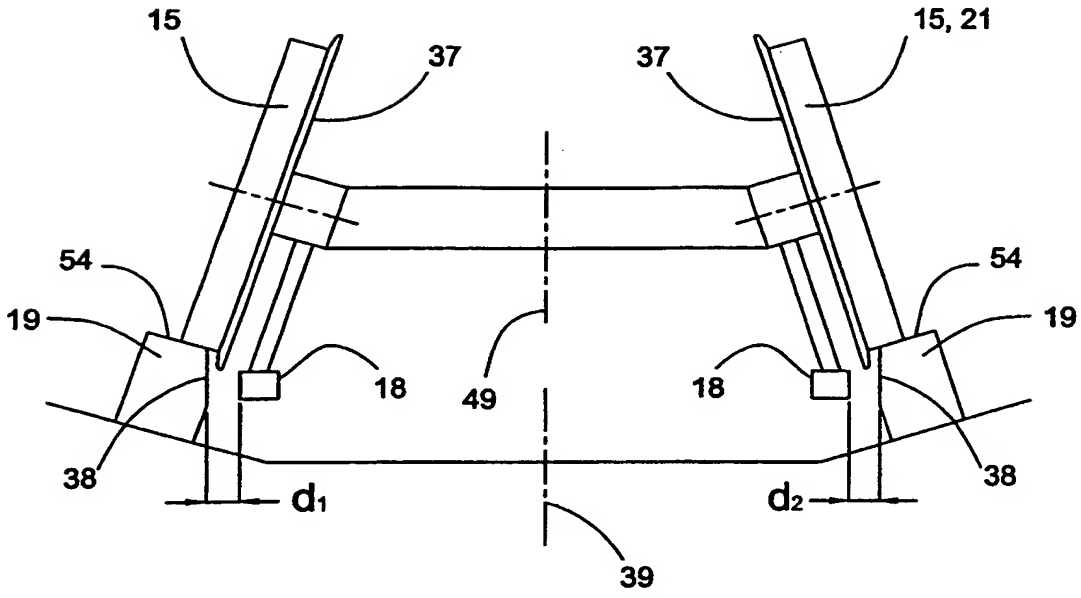



Figure 9

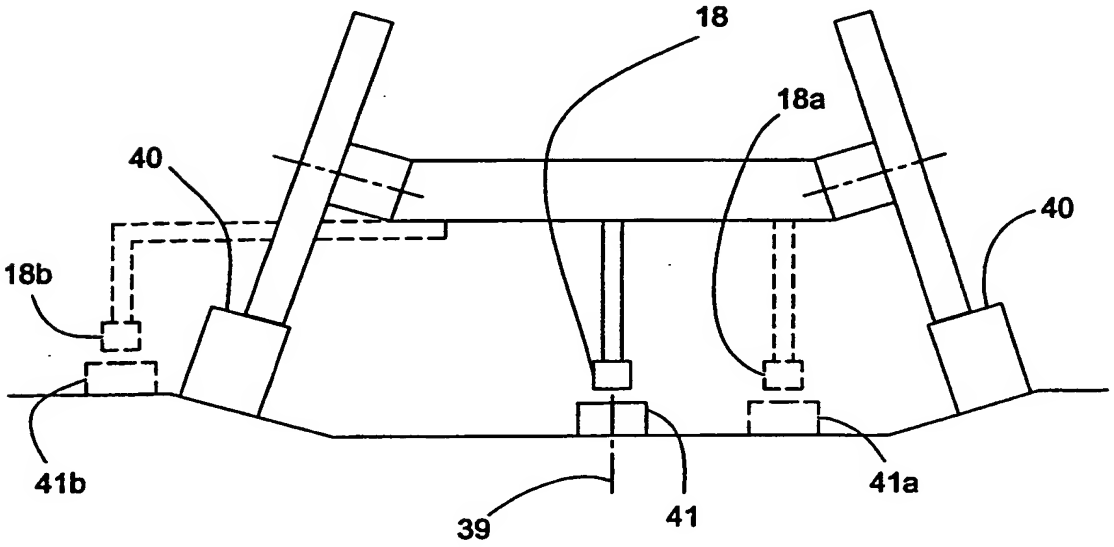



Figure 10

Scott Phillip Neal TAYLOR
US Completion of PCT/AU00/00898
A VEHICLE WITH A STEERABLE WHEELSET
Docket: CU-2825

**SUBSTITUTE SPECIFICATION**

# A VEHICLE WITH A STEERABLE WHEELSET

## TECHNICAL FIELD

This invention relates to a vehicle with a steerable wheelset. Whilst the invention is primarily described with an embodiment particularly suited for use with Automated Guideway Transit (AGT) systems of the type which use small, individual vehicles, capable of operating at high speeds, the present invention is also suitable for use with a variety of other rail or guideway systems.

## BACKGROUND

There are a number of known vehicles adapted to travel on rail or guideway systems which have steerable wheelsets.

One such system is disclosed in US Patent 4,982,671 (Chollet et al), and relates to a track guided vehicle. Such a vehicle is supported on bogies, where each bogie contains two wheelsets. Magnetic (or other) sensors are used to detect the lateral position of the bogie with respect to the track on which it is running. At least one sensor detects the angle between the two wheelsets. The two wheelsets are connected via linkages and actuators, such that the angle between the wheelsets can be altered to steer the bogie. A servo-control circuit receives signals from the sensors and controls the actuators to steer the wheelsets in response to the detected lateral position of the bogie.

Another known system is disclosed in European Patent 374,290 (Girod et al), and relates to a track guided vehicle. Such a vehicle comprises four wheels that can be independently steered. Laser sensors, located at the front and rear of the vehicle, are used to detect the difference between the track centreline and the vehicle longitudinal axis. A servo-control mechanism controls the steering actuators in order to steer the wheels in response to the sensed signals.

A disadvantage of both of these arrangements is that the lateral forces at the wheel-rail contact zone must serve a dual function, namely to steer the bogie and to oppose any lateral force, such as the centrifugal force experienced by a vehicle while cornering. Consequently the force available for steering the bogie is limited to the difference between the total available force and that already being used to oppose any external lateral forces. In a rail application where a steel wheel rolls on a steel rail, the total available force may be very low. This available force may be substantially required to react centrifugal force, with very little remaining force available to steer the wheelset leading to frequent contact between the wheel flanges and the rails.

A further known system is disclosed in US Patent 5,730,064 (Bishop), and relates to a self-steering bogie for track guided vehicle. The wheelsets are arranged such that a curvature in the rail generates a twist angle between the two wheelsets in the bogie when viewed in end elevation. The mechanism connecting the two wheelsets is arranged so as to steer the wheelsets, in response to rail curvature. A disadvantage of this arrangement when applied to small vehicle guideway systems, which typically use much sharper curves than normal rail systems, is the steer error resulting from twist angle supplied by rapidly changing superelevation. This may add to or subtract from the ideal steering angle required, causing the wheelset to deviate from its idealised path.

Preferably the present invention overcomes the above mentioned disadvantages by providing a vehicle with a steerable wheelset in which the effect of lateral or disturbing forces on the vehicle is minimised.

**SUMMARY OF INVENTION**

In one aspect the present invention is a vehicle with at least one steerable wheelset adapted to run on a guideway having two primary running faces laterally offs t about

a guideway centreline, the wheelset comprising a pair of wheels, each wheel located on opposite sides of the wheelset adapted to

engage with a respective one of the two primary running faces, the vehicle further comprising sensing means for sensing lateral displacement of the wheelset with respect to a longitudinally disposed reference path, the sensing means producing a signal for a control system operably connected to an actuating means to steer the wheels in response to the sensed lateral displacement, **characterised in that** the axes of rotation of the wheels and the primary running faces are inclined downwardly towards the guideway centreline.

In a first embodiment each wheel exerts an engagement force with its respective primary running face, the engagement force on each wheel comprising a perpendicular component to its respective primary running face and a parallel component to its respective primary running face substantially transverse to the guideway centreline, wherein horizontal forces acting on the wheelset substantially perpendicular to the guideway centreline are substantially resisted by the sum of of the horizontal vectors of the perpendicular components.

In a second embodiment embodiment each wheel exerts an engagement force with its respective primary running face at a contact zone, the engagement force on each wheel comprising a first component perpendicular to its respective primary running face and a second component parallel to its respective primary running face substantially transverse to the guideway centreline, wherein a first plane perpendicular to the axis of rotation of one of the wheels passes through its respective contact zone, and a second plane perpendicular to the axis of rotation of the other wheel passes through its respective contact zone, the first and second planes intersecting along an intersection line disposed above and between the wheels, wherein horizontal forces acting on the wheelset substantially transverse to

the guideway centreline at or near the intersection line are substantially resisted by perpendicular components of the engagement forces acting at the primary running faces, such that substantially all of the parallel components of the engagement forces acting at the primary running faces are available to steer the wheelset.

Preferably the intersection line passes through the centre of gravity of vehicle.

It is preferred that the sensing means comprises at least one sensor located either ahead or behind the wheelset, or laterally offset with the wheelset. Alternatively the sensing means comprises at least two sensors, one of which is located ahead of the wheelset and the other is located behind the wheelset.

It is preferred that the longitudinally disposed reference path is substantially contiguous with the guideway centreline.

Alternatively, it is preferred that the longitudinally disposed reference path is substantially parallel to, but laterally offset from the guideway centreline.

It is preferred that a secondary running face lies immediately adjacent to, and substantially parallel to, at least one primary running face.

It is preferred that the longitudinally disposed reference path is contiguous with the second running face.

Alternatively, it is preferred that a secondary running face lies immediately adjacent to and substantially parallel to each primary running face and the longitudinally disposed reference path is contiguous with the lateral centreline between the respective two secondary running faces.

It is preferred that at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

It is preferred that the control system calculates a virtual longitudinally disposed reference path which is not necessarily parallel or contiguous with the guideway centreline.

## BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is an example of a vehicle according to the prior art, with two steerable wheelsets and incorporating steering sensors, actuators and a controller;

Figure 2 is a wheelset as found in the vehicle in Figure 1, showing the forces acting at the wheel-to-guideway running faces;

Figure 3 is a graph representing a typical relationship between side-force and slip angle for a wheel of the wheelset in Figure 2, and showing the force available for steering the wheels;

Figure 4 shows a schematic representation of a vehicle in accordance with a first embodiment of the present invention;

Figure 5 shows a schematic representation of a vehicle as shown in figure 4 when the vehicle is in a turn;

Figure 6 is a wheelset of the vehicle as shown in Figures 4-5, showing the forces acting at the wheel-to-guideway running faces;

Figure 7 is a graph similar to Figure 3, showing the force substantially available to steer the wheels in accordance with the first embodiment of the present invention;

Figure 8 is an illustration of the forces which act on the wheelset of the vehicle shown in Figure 6.

Figure 9 is a wheelset and rails as described in a second embodiment of the present invention;

Figure 10 shows a wheelset which is following a longitudinally disposed reference path other than the guideway centreline or secondary running face, according to a third embodiment of the present invention.

## MODE OF CARRYING OUT THE INVENTION

Figures 1 and 2 show a vehicle running on a guideway (or track) of the type described in prior art. Such a vehicle incorporates two steerable wheelsets 1, attached to a vehicle body 2, and each wheelset 1 comprising axle 10 and two wheels 12. Steering actuators 3, are used to control the angle of the wheels with respect to the body. Sensors 4, detect the path error between the vehicle and guideway 5. A controller 6, processes the signals from the sensors and provides a control output to steering actuators 3. Upon detecting a path error, wheelsets 1 are steered in order to minimise the error.

In such a vehicle, axles 10 are substantially horizontal, as shown in Figure 2. When a lateral force F is applied to the vehicle body 2, it is reacted by the wheel-to-guideway engagement forces. These reaction forces can be resolved into perpendicular components, $A_N$ and $B_N$, and parallel components, $A_T$, $B_T$. When a wheel is steered at an angle to its heading, generating a slip angle, small levels of slip at its contact zone generate a lateral force ($A_T$, $B_T$). This lateral force is related

to this slip angle, with a typical relationship of the form shown in the graph of Figure 3. Such a relationship depends on both the wheel and guideway materials, along with their surface texture and lubrication. The available side force reaches a maximum at a slip angle $\delta_1$, beyond which no additional side force is available. In the example shown in Figure 2, wheelset 1 is steered so that lateral force F is reacted by a combination of $A_T$ and $B_T$ where $A_T$ is equal to $C_1$ as shown graphically in Figure 3. To generate a force $C_1$ wheelset 1 must be steered so that wheel 12 generates a slip angle $\delta_0$ to its heading. Only the remaining force $C_2$ is available to steer wheelset 1. If the required side force exceeds $C_2$, steering control is lost, the wheel slides in the direction of force F and is unable to follow a desired path. In such an event, the wheelset must rely on other means, such as wheel flanges, to ensure it remains safely on the guideway.

Figures 4 to 6 show a first embodiment of a vehicle according to the present invention comprising steerable wheelsets 21, each comprising axle 26 and two wheels 15 running on primary running faces 54 of guideway 19, attached to vehicle body 16. Steering actuators 17, are used to control the angle of wheelsets 21 with respect to vehicle body 16. Sensors 18, detect the lateral displacement between the vehicle and guideway 19. Controller 20 processes the signals from sensors 18, and provides an output to the steering actuators as a function of the lateral displacement of wheelset 21 with respect to guideway centreline 39. Upon detecting a lateral displacement error, wheelsets 21 are steered in order to minimise the error.

As shown in Figure 6, axes of rotation 28 of wheels 15 (mounted to stub axles 25) are inclined downwardly towards guideway centreline 39, as are primary running faces 54 at the wheel-to-guideway rolling interface. When a lateral force F is similarly applied to vehicle body 16, it is reacted by the wheel-to-guideway engagement forces. These can be resolved into first perpendicular components, $P_N$ and $Q_N$ and second parallel components, $P_T$ and $Q_T$. Each of these has a

component parallel to the applied lateral force F, and in combination react against this force.

On entering a turn, sensors 18 detect the deviation of the vehicle from guideway centreline 39, and controller 20 responds by steering wheelset 21 in the direction to reduce the deviation to zero. The resulting slip angle $\delta$ produces lateral forces at the wheel-to-guideway interface, causing the vehicle to accelerate toward the instantaneous centre of curvature. The centrifugal force F, acting on the centre of gravity 50 of the vehicle, is substantially reacted by an increase in the normal force, $P_N$, on the outer wheel, rather than an increase of the tangential forces, $P_T$ and $Q_T$. If $P_T$ and $Q_T$ are small, then the wheels do not need to be operating at a very large slip angle $\delta_o$ as shown in Figure 7. As a result, most of the maximum available tangential force, $C_2$, can be used to steer wheelset 21 and maintain its alignment with guideway centreline 39.

It is preferred that vehicle centre of gravity 50 and wheels 15 are arranged such that centre of gravity 50 is near the intersection line 52 of wheel planes 51. In this configuration, the centrifugal forces or external disturbance forces acting on centre of gravity 50, are substantially resisted by an increase in the normal force, $P_N$, on the outer wheel, and corresponding decrease in the normal force $Q_N$ on the inner wheel. As shown in Fig 8., the difference between the horizontal component $P_H$ of $P_N$ and the horizontal component $Q_H$ of $Q_N$, substantially resists the sum of the centrifugal or external disturbance force F.

Figure 9 depicts a second embodiment of the present invention, where the vehicle has a wheelset 21 comprising wheels 15 adapted to run on a guideway in the form of rails 19. Sensors 18 detect the proximity $d_1$, $d_2$ of the respective wheel 15 to the respective secondary running face 38 on rail 19. Sensed proximities $d_1$, $d_2$ are

averaged to generate the lateral position of the centreline 49 of the wheelset 21, with respect to the guideway centreline 39. In this embodiment each of the wheels 15 have a respective flange 37. Flange 37 engages with respective secondary running face 38 on rail 19 in the event of a steering failure, or excessive side load imparted on the vehicle via lateral acceleration or side wind loads. In other not shown embodiments, sensors 18 may detect the proximity of the wheels to some other feature on rail 19.

In a third embodiment of the invention as shown in Figure 10, sensors 18 may sense a different path to that of guideway running faces 40. In this embodiment a longitudinally disposed reference path 41, corresponding to the guideway centreline 39, is used. However, it should be understood that such a path may physically lie between guideway running faces 40, as depicted by phantom lines as reference path 41a and sensor 18a, or outside guideway running faces 40, as depicted by phantom lines as reference path 41b and sensor 18b. Alternatively the reference path may be a virtual path, bearing some predetermined varying relationship to the guideway running faces 40.

In other not shown embodiments other means of supporting and steering the wheels may be used. These include steering of individual wheels about individual steering axes, rather than steering complete wheelset 21. Sensors 18, are attached to wheelset 21, and sense its lateral displacement with respect to each primary running face 54 of guideway 19 and hence with respect to guideway centreline 39. Sensors 18 are preferably located ahead of wheelset 21 and are connected to controller 20. In other not shown embodiments, sensors 18 may be located ahead, beside, and/or even behind the wheels.

Sensors 18, controller 20 and actuators 17 may include hydraulic or electrical devices and combinations thereof.

It will be recognised by persons skilled in the art that numerous variations and modifications may be made to the invention without departing from the spirit and scope of the invention.